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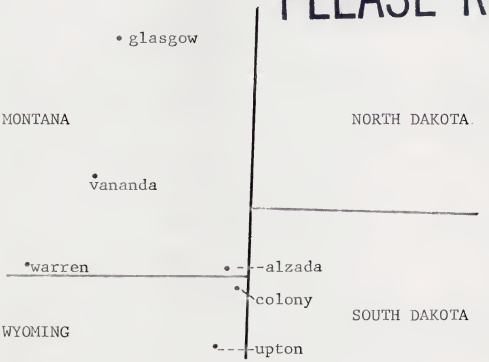

OLD WEST REGIONAL COMMISSION GRANT NO. 10570164

SUBMITTED TO: OLD WEST REGIONAL COMMISSION
HEDDEN-EMPIRE BUILDING
SUITE 228
BILLINGS, MONTANA 59101

PREPARED BY: S. JOHNSON, D. HEMMER, AND R. BECK

MONTANA DEPARTMENT OF STATE LANDS

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INTRODUCTION

This study is an update of a study intiated by the Montana Department of State Lands through funding from the Old West Regional Commission. It was developed to understand the problems associated with bentonite mine reclamation and to then recommend how such problems can be alleviated. Bentonite, a commercially used montmorillonitic clay, is mined in South Dakota, Montana, and Wyoming.

A general background and description of deposits, mining, and past reclamation efforts is given in the original report: Bentonite Mining Related Reclamation Problems in the Northwestern States. October, 1977. Helena, Montana. Montana Department of State Lands - 94 p.

The materials and methods are described in detail (p. 11) in the original report. Briefly, seven sites, Colony, Upton, Greybull, and Frannie, Wyoming, and Glasgow, Alzada, and Vananda, Montana, were selected for study. Experimental plots were designed in order to compare success of different species, seeding rates, surface treatments, and season of seeding.

Tables 1-4, reproduced from the original report, show the various seed mixes and seeding rates.

Plots were analyzed for productivity, canopy cover, and stems per unit area (density) after the second and third growing seasons.

The data for the second growing season are given in appendix B (p. 55) of the original report. Data for the third growing season are presented in appendix B of this volume.

RESULTS AND DISCUSSION

SURFACE TREATMENTS

Furrowed and gouged subplots were compared to the control subplots for all subplots containing measurable vegetation. Only those species producing consistent stands of vegetation were used in the analysis.

Although some of the species showed significant differences[1] during the 1977 growing season these differences did not carry over to the 1978 growing season. This is probably due to the generally higher precipitation which would have overcome any advantage of furrowing or gouging. The additional moisture retention in the furrows and gouges would only have been important under conditions of moisture stress.

[1]Using the Student's t-test at 95 percent probability level.

TABLE 1.--Seeding mixture for Alzada, Montana, Colony, and Upton, Wyoming

Common name	Scientific name	Abbreviation
Yellow sweet clover	Melilotus officinalis	Meof
White prairie clover	Petalostemon candidum	Peca
Crested wheatgrass (Nordan)	Agropyron desertorum	Agde
Crested wheatgrass (Fairway)	Agropyron cristatum	Agcr
Western wheatgrass	Agropyron smithii	Agsm
Pubescent wheatgrass	Agropyron trichophorum	Agtri
Streambank wheatgrass	Agropyron riparium	Agri
Siberian wheatgrass	Agropyron sibiricum	Agsi
Thickspike wheatgrass	Agropyron dasystachium	Agda
Basin wildrye	Elymus cinereus	Elci
Buffalo grass	Buchloe dactyloides	Buda
Indian ricegrass	Oryzopsis hymenoides	Orhy
Big sage	Artemesia tridentata	Artr
Fourwing saltbush	Atriplex canescens	Atca
Nuttalls saltbush	Atriplex nuttallii	Atnu
Greasewood	Sarcoleatus vermicutatus	Save
Rubber rabbitbrush	Chrysothamnus nauseosus	Chna
Canadian wildrye	Elymus canadensis	Elca
Bottlebrush squirreltail*	Sitanion hystrix	Sihy
Shadscale saltbush*	Atriplex confertifolia	Atco

*Seeded at Upton, Wyoming only.

Mixtures	Lb./acre
ACU-1 - Western wheatgrass	6
Green needlegrass	4
Yellow sweet clover	2
	12
ACU-2 - Thickspike wheatgrass	3
Western wehatgrass	6
Green needlegrass	4
Yellow sweet clover	2
	15
RP-1 - Western wheatgrass	6.0
Pubsecent wheatgrass	4.5
Green needlegrass	4.0
Yellow sweet clover	.5
	15.0

TABLE 2.--Seeding mixture for Glasgow, and Vananda, Montana

Common name	Scientific name	Abbreviation
Yellow sweet clover	Melilotus officinalis	Meof
White prairie clover	Patalostemon candidum	Peca
Crested wheatgrass (Nordan)	Agropyron desertorum	Agde
Crested wheatgrass (Fairway)	Agropyron cristatum	Agcr
Western wheatgrass	Agropyron smithii	Agsm
Pubescent wheatgrass	Agropyron trichophorum	Agtri
Streambank wheatgrass	Agropyron riparium	Agri
Siberian wheatgrass	Agropyron sibiricum	Agsi
Thickspike wheatgrass	Agropyron dasystachium	Agda
Basin wildrye	Elymus cinereus	Elci
Buffalo grass	Buchloe dactyloides	Buda
Indian ricegrass	Oryzopsis hymenoides	Orhy
Big sage	Artemesia tridentata	Artr
Rubber rabbitbrush	Chrysothamnus nauseosus	Chna

Mixtures	Lb./acre
GV-1 - Western wheatgrass	8
Green needlegrass	3
Thickspike wheatgrass	5
Yellow sweet clover	2
	17
RP-1 - Western wheatgrass	6.0
Pubsecent wheatgrass	4.5
Green needlegrass	4.0
Yellow sweet clover	.5
	15.0

TABLE 3.--Seeding mixture for Greybull, Wyoming

Common name	Scientific name	Abbreviation
Crested wheatgrass (Nordan)	Agropyron desertorum	Agde
Crested wheatgrass (Fairway)	Agropyron cristatum	Agcr
Western wheatgrass	Agropyron smithii	Agsm
Pubescent wheatgrass	Agropyron trichophorum	Agtri
Streambank wheatgrass	Agropyron riparium	Agri
Thickspike wheatgrass	Agropyron dasystachium	Agda
Siberian wheatgrass	Agropyron sibiricum	Agsi
Basin wildrye	Elymus cinereus	Elci
Indian ricegrass	Oryzopsis hymenoides	Orhy
Bottlebrush squirreltail	Sitanion hystrix	Sihy
Big sage	Artemesia tridentata	Artr
Fourwing saltbush	Atriplex canescens	Atca
Nuttalls saltbush	Atriplex nuttallii	Atnu
Greasewood	Sarcobatus vermiculatus	Save
Rubber rabbitbrush	Chrysothamnus nauseosus	Chna
Winterfat	Ceratoides lanata	Cela
Alkali sacaton	Sporobolus airoides	Spai

Mixtures	Lb./acre
WG-1 - Western wheatgrass	4
Crested wheatgrass	4
Indian ricegrass	3
	11
WG-2 - Western wheatgrass	3
Thickspike wheatgrass	3
Nuttalls saltbush	1
	7
RP-1 - Western wheatgrass	6.0
Pubsecent wheatgrass	4.5
Green needlegrass	4.0
Yellow sweet clover	.5
	15.0

TABLE 4.--Seeding mixture for Warren, Montana

Common name	Scientific name	Abbreviation
Western wheatgrass	Agropyron smithii	Agsm
Pubescent wheatgrass	Agropyron trichophorum	Agtri
Streambank wheatgrass	Agropyron riparium	Agri
Thickspike wheatgrass	Agropyron dasystachium	Agda
Bottlebrush squirreltail	Sitanion hystrix	Sihy
Fourwing saltbush	Atriplex canescens	Atca
Nuttalls saltbush	Atriplex nuttallii	Atnu

Mixtures	Lb./acre
WG-1 - Western wheatgrass	4
Crested wheatgrass	4
Indian ricegrass	3
	11
WG-2 - Western wheatgrass	3
Thickspike wheatgrass	3
Nuttalls saltbush	1
	7

SEEDING RATE

Seeding rates greater than those recommended did not have significant effect on production or canopy cover. Although rates below those recommended produced poorer stands the first and second growing season, by the third growing season these stands had canopy cover and production similar to those seeded at or above the recommended rate. All seedings had increased canopy cover, production, and density by a factor of 2 or more from the second to third growing season. This is probably due at least in part to the high moisture availability during the 1978 growing season.

ADAPTABILITY OF INDIVIDUAL SPECIES

No difference in species adaptability could be shown following a third growing season. As stated in the first report, Nordan crested wheatgrass and Fairway crested wheatgrass, Thickspike wheatgrass, Streambank wheatgrass, and Western grew most consistently. Basin wildrye and Canadian wildrye, were erratic in success. Site-to-site variability is so great that species should not be compared to one another for all sites simultaneously.

The canopy cover, density, and production for most species at least doubled the third growing season compared to values of the previous growing season. Nuttalls and white prairie clover appear to have been almost completely eliminated from all plots. This may be due to browsing by wildlife, or possibly to sampling error.

An analysis of species at the individual plots follows.

Vananda, Warren, and Greybull

For those reasons cited in the original report, the Vananda, Greybull, and Warren plots were not sampled.

Alzada

Growth during the 1978 growing season was similar to that of the previous year. Nordan and Fairway crested again provided the greatest canopy cover. Streambank showed significant improvement, which would appear to be correlated to an increase in rainfall. Western wheatgrass, Pubescent wheatgrass, and Thickspike wheatgrass also did well. Basin wildrye and Siberian wheatgrass provided less cover, however they, like Streambank wheatgrass, showed marked improvement relative to the other species. Although still the least productive, Canadian wildrye and Indian ricegrass also increased from the second to third growing season. Most of the increase is again attributed to the increase in rainfall. Greasewood and Yellow sweet clover remained successful, while Nuttall's saltbush, Big sage, Rubber rabbitbrush, Fourwing saltbush, and White prairie clover had not become established.

Colony

Nordan and Fairway crested wheatgrass remained the most successful species. Intermediately successful were the Streambank wheatgrass, Thickspike wheatgrass, Western wheatgrass, Pubescent wheatgrass, and Siberian wheatgrass. Streambank wheatgrass increased some while Thickspike wheatgrass decreased some. Basin wildrye, Canadian wildrye, and Indian ricegrass improved during the third growing season although they were least successful. It is again assumed that this is in response to the favorable rainfall. Although not recorded previously, Buffalo grass was found during the 1978 growing season. This may be due to invasion of seed from outside the plot, or, more likely from seed that had previously not germinated, but did, under the high moisture regime of 1978. Yellow sweet clover also appeared. There are still no shrubs growing on the Colony plot.

Glasgow

The 1978 results at Glasgow were similar to the 1977 results. Thickspike wheatgrass, Fairway crested wheatgrass, and Streambank wheatgrass were most successful, followed by Western wheatgrass, Pubescent wheatgrass, and Nordan crested wheatgrass and Basin wildrye. Basin wildrye grew on

spring seeded plots where it has not grown for 2 seasons. Indian ricegrass had persisted but did not respond to the increased rainfall here, as it had at the other plots. Yellow sweet clover showed no increase.

Buffalo grass and Rubber rabbitbrush, although not recorded for the previous growing season did occur this year, presumably in response to the increased moisture. However, Big sage and White prairie clover have still failed to grow here.

Upton

Nordan crested wheatgrass and Fairway crested wheatgrass were most productive here, followed by Streambank wheatgrass, Thickspike wheatgrass, Western wheatgrass, Siberian wheatgrass, and Pubescent wheatgrass and Canadian wildrye. Basin wildrye, Indian ricegrass, Buffalo grass, and Squirreltail were less successful.

Yellow sweet clover, Greasewood, and Fourwing saltbush persisted through a third growing season. Big sage and Nuttall's saltbush appear to have died out, however, it is more likely that these were grazed by wildlife and consequently overlooked in the sampling process.

Rubber rabbitbrush, Shadscale, and Winterfat have still not grown on the plots.

FERTILIZATION

As in the second growing season, no significant differences were measured during the third season for species in the fertilized and unfertilized plots.

SEASON OF SEEDING

Differences still persist between the spring and fall seedings, with the springs seedings having consistently lower canopy cover, density, and biomass.

CONCLUSIONS

Those conclusions presented in the 1977 report are still valid.

Of interest is the growth of Buffalo grass the third season after planting. It is unlikely that Indian ricegrass invaded from off site, thus supporting one of the original conclusions: certain species, while not individually establishing good stands, should be utilized to increase plant diversity.

RECOMMENDATIONS

In addition to those recommendations presented in the original report, the following are recommended:

1. Increase the species diversity of the seed mixture. It is apparent that although some seed may not germinate during the first growing season, it may germinate later, increasing diversity and thus reducing the dependence on natural reinvasion of a site to create diversity.

2. Additional research on seed dormancy and germination could increase the success rate for seeding of those species which in the past have apparently failed to germinate and/or have germinated at very slow rates.

APPENDIX A

WEATHER DATA

TABLE A-1.--1977 Climatological data

[Inches of precipitation]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
						Montana							
Glasgow--	0.42	0.12	0.11	0.17	1.83	1.16	0.78	0.58	2.62	0.40	0.24	0.86	9.29
Albion---	0.62	0.02	1.19	0.48	1.01	1.80	1.92	0.92	2.17	2.73	0.72	0.81	15.11
Forsyth--	0.88	0.20	1.19	0.14	3.13	0.53	0.73	1.86	1.32	0.93	0.62	1.20	12.73
						Wyoming							
Deaver---	0.38	0.01	0.27	0.24	1.22	0.69	0.49	1.53	0.54	0.29	T	0.17	5.83
Lovell---	0.36	T	0.56	0.52	0.93	1.02	0.63	1.27	0.53	0.42	0.07	0.43	6.74
Greybull-	0.51	0.01	0.63	0.79	0.72	0.24	0.80	1.58	0.68	T	0.09	0.38	6.43
Colony---	0.54	0.15	1.94	0.31	1.62	3.00	0.80	2.23	2.52	2.59	0.70	0.92	17.32
Upton----	0.63	0.37	0.84	0.80	1.14	2.19	1.37	2.41	0.75	1.34	0.80	0.76	13.40

TABLE A-2.--1978 Climatological data

[Inches of precipitation]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
						Montana							
Glasgow--	0.19	0.40	0.25	0.51	3.65	2.72	2.63	0.16	4.14	0.28	0.48	0.45	15.86
Albion---	---	---	---	---	---	---	---	0.58	0.79	0.20	0.77	0.27	---
Forsyth--	0.33	0.44	0.21	0.67	6.50	1.21	1.13	0.37	4.94	0.27	2.04	0.64	18.75
						Wyoming							
Deaver---	0.27	0.63	T	0.87	1.54	0.10	0.28	0.41	1.79	0.05	0.60	0.30	6.84
Lovell---	0.31	0.87	0.02	1.70	2.61	0.18	0.72	0.18	2.32	T	0.40	0.30	9.61
Greybull-	0.92	0.74	0.13	2.09	1.31	0.07	0.77	0.65	1.93	0.04	0.90	0.68	10.32
Colony---	0.09	0.88	0.12	1.35	5.31	1.15	3.35	0.17	0.53	0.40	0.94	0.21	14.50
Upton----	0.27	0.68	0.23	1.61	6.03	0.77	3.23	1.68	0.31	0.37	0.64	0.91	16.73

T = trace.

APPENDIX B

VEGETATION DATA

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TABLE B-1.--Vegetation data from Alzada

Species	Season / Treatment	Canopy cover (percent) Spring	Canopy cover (percent) Fall	Density (stems/m^2) Spring	Density (stems/m^2) Fall	Production (grams/m^2) Spring	Production (grams/m^2) Fall
Siberian wheatgrass	Control	10.0	10.0	155	---	21.8	---
	Furrowed	5.5	17.5	---	163.2	---	32.7
	Gouged	7.5	2.7	245.9	13.8	22.2	---
Western wheatgrass	Control	26.0	22.5	818.1	574.1	258.4	106.6
	Furrowed	12.7	17.5	103.3	232.5	7.5	88.7
	Gouged	10.0	6.8	275.6	218.1	38.3	21.9
Thickspike wheatgrass	Control	*	6.7	*	284.1	*	38.5
	Furrowed	*	31.7	*	493.7	*	63.4
	Gouged	*	25.4	*	718.2	*	66.2
Streambank wheatgrass	Control	16.2	25.0	585.5	447.8	49.7	46.4
	Furrowed	10.0	27.5	71.2	462.1	45.9	26.5
	Gouged	16.7	31.3	292.7	1,148.7	56.2	123.1
Pubescent wheatgrass	Control	9.0	7.7	83.3	---	21.7	---
	Furrowed	5.0	17.7	86.1	327.2	18.8	87.1
	Gouged	5.0	26.6	---	218.2	---	40.5
Nordan crested wheatgrass	Control	*	35.0	*	292.8	*	67.8
	Furrowed	*	28.7	*	365.1	*	34.2
	Gouged	*	32.5	*	780.1	*	142.1
Fairway crested wheatgrass	Control	*	27.5	*	470.7	*	73.8
	Furrowed	*	45.0	*	361.4	*	89.8
	Gouged	*	43.7	*	663.1	*	99.9
Basin wildrye	Control	15.0	5.5	---	37.1	---	---
	Furrowed	---	---	---	---	---	---
	Gouged	1.0	4.0	1.7	34.4	---	2.8
Canadian wildrye	Control	---	---	---	---	---	---
	Furrowed	---	---	---	---	---	---
	Gouged	20.0	---	---	---	---	---
Indian ricegrass	Control	*	3.0	*	117.1	*	5.1
	Furrowed	*	5.7	*	13.8	*	1.5
	Gouged	*	4.3	*	6.9	*	0.0
Yellow sweet clover	Control	1.0	---	---	---	---	---
	Furrowed	50.0	30.0	---	25.8	---	---
	Gouged	10.0	27.5	34.4	344.4	---	---
Greasewood	Control	2.0	---	---	---	---	---
	Furrowed	---	10.0	---	---	---	---
	Gouged	---	20.0	---	---	---	---

*This species was not seeded here in the spring.

TABLE B-2.--Vegetation data from Colony

Species	Season Treatment	Canopy cover (percent) Spring	Canopy cover (percent) Fall	Density (stems/m^2) Spring	Density (stems/m^2) Fall	Production (grams/m^2) Spring	Production (grams/m^2) Fall
Siberian wheatgrass	Control	3.5	19.25	---	46.5	---	69.8
	Furrowed	3.0	15.0	17.2	203.7	---	52.7
	Gouged	---	17.5	---	154.8	---	23.3
Western wheatgrass	Control	17.5	50.0	172.1	526.9	14.6	61.8
	Furrowed	20.0	46.2	241.1	929.9	28.1	168.3
	Gouged	20.0	32.5	172.3	301.5	18.6	31.7
Thickspike wheatgrass	Control	*	50.0	*	129.7	*	125.5
	Furrowed	*	42.5	*	826.7	*	103.1
	Gouged	*	45.0	*	608.6	*	78.5
Streambank wheatgrass	Control	15.0	52.5	298.6	907.1	22.3	51.4
	Furrowed	28.8	52.5	533.9	835.3	46.8	68.7
	Gouged	8.3	40.0	154.9	543.3	13.7	61.0
Pubescent wheatgrass	Control	21.8	40.0	264.0	183.6	54.5	58.8
	Furrowed	27.5	45.0	150.6	258.4	---	72.0
	Gouged	10.0	38.3	68.8	441.1	14.0	104.6
Nordan crested wheatgrass	Control	*	60.0	*	835.3	*	100.0
	Furrowed	*	53.7	*	579.9	*	140.1
	Gouged	*	55.0	*	633.8	*	---
Fairway crested wheatgrass	Control	*	57.5	*	1,291.5	*	142.6
	Furrowed	*	75.0	*	1,351.7	*	185.3
	Gouged	*	58.3	*	1,343.4	*	67.1
Basin wildrye	Control	5.2	16.3	25.8	132.0	---	34.3
	Furrowed	3.5	5.6	12.9	41.8	13.5	8.4
	Gouged	2.0	30.0	8.5	183.8	2.4	60.3
Canadian wildrye	Control	10.0	---	51.7	---	---	---
	Furrowed	21.7	---	172.2	---	34.4	---
	Gouged	10.0	---	---	---	---	---
Indian ricegrass	Control	---	12.5	---	103.4	---	7.5
	Furrowed	---	10.0	---	60.2	---	2.6
	Gouged	---	9.0	---	---	---	---
Buffalo grass	Control	---	3.0	---	---	---	---
	Furrowed	---	2.7	---	---	---	---
	Gouged	---	1.0	---	---	---	---
Yellow sweet clover	Control	---	---	---	---	---	---
	Furrowed	---	---	---	---	---	---
	Gouged	3.0	25.0	---	---	---	---

*This species was not seeded here in the spring.

TABLE B-3.--Vegetation data from Glasgow

Species	Season / Treatment	Canopy cover (percent) Spring	Canopy cover (percent) Fall	Density (stems/m^2) Spring	Density (stems/m^2) Fall	Production (grams/m^2) Spring	Production (grams/m^2) Fall
Siberian wheatgrass	Control	---	8.7	---	---	---	---
	Furrowed	---	10.0	---	---	---	---
	Gouged	7.5	5.0	---	---	---	55.6
Western wheatgrass	Control	11.4	20.0	120.5	346.2	13.5	36.9
	Furrowed	17.7	15.0	315.2	220.4	27.4	21.3
	Gouged	24.2	21.4	341.7	558.0	32.9	36.2
Thickspike wheatgrass	Control	21.3	28.8	366.8	502.9	20.6	35.9
	Furrowed	28.2	61.6	371.6	776.8	16.9	78.9
	Gouged	28.0	50.0	354.8	1,044.9	26.3	79.9
Streambank wheatgrass	Control	10.0	27.5	225.1	826.7	14.5	41.6
	Furrowed	9.2	35.0	149.3	396.0	6.7	32.5
	Gouged	26.3	47.5	594.4	620.0	31.9	47.3
Pubescent wheatgrass	Control	12.3	20.0	101.6	194.6	10.5	33.8
	Furrowed	16.7	31.3	68.8	167.1	14.4	24.8
	Gouged	22.5	40.0	103.4	310.1	9.6	44.0
Nordan crested wheatgrass	Control	12.0	25.0	227.4	137.8	22.5	27.5
	Furrowed	18.3	40.0	155.1	551.1	14.8	46.9
	Gouged	5.0	35.0	137.6	275.5	15.5	56.8
Fairway crested wheatgrass	Control	8.4	33.8	206.7	447.8	11.5	45.5
	Furrowed	15.0	33.8	196.4	461.7	13.1	26.7
	Gouged	31.7	57.5	206.7	447.8	17.2	39.4
Basin wildrye	Control	---	15.0	---	182.5	---	22.8
	Furrowed	1.0	22.3	---	261.7	---	27.4
	Gouged	5.3	35.0	---	225.6	---	24.2
Big sage	Control	---	---	---	---	---	0.7
	Furrowed	---	---	---	---	---	---
	Gouged	---	---	---	---	---	---
Indian ricegrass	Control	1.0	10.0	---	51.6	---	1.6
	Furrowed	---	11.7	---	62.0	---	8.3
	Gouged	---	13.0	---	206.7	---	11.5
Buffalo grass	Control	---	3.0	---	---	---	---
	Furrowed	---	1.5	---	---	---	---
	Gouged	---	---	---	---	---	---
Yellow sweet clover	Control	22.5	78.3	234.2	953.0	---	---
	Furrowed	56.2	66.3	562.7	441.2	---	---
	Gouged	45.2	93.3	347.8	852.5	---	---
Rubber rabbitbrush	Control	1.0	1.0	---	---	---	17.7
	Furrowed	---	1.0	---	---	---	---
	Gouged	---	---	---	---	---	---

TABLE B-4.--Vegetation data from Upton

[NOTE: All seeding here was done in the spring.]

Species	Season / Treatment	Canopy cover (percent) Spring	Density (stems/m^2) Spring	Production (grams/m^2) Spring
Siberian wheatgrass	Control	32.2	640.0	281.7
	Furrowed	29.2	544.2	142.9
	Gouged	32.5	803.3	---
Western wheatgrass	Control	43.6	671.2	85.3
	Furrowed	40.7	489.1	67.8
	Gouged	40.0	983.2	78.6
Thickspike wheatgrass	Control	45	238.2	112.1
	Furrowed	58.3	907.0	141.0
	Gouged	40.0	838.2	110.0
Streambank wheatgrass	Control	50.7	1,229.7	222.1
	Furrowed	51.9	994.3	124.5
	Gouged	40.3	891.1	90.8
Pubescent wheatgrass	Control	32.8	235.9	85.8
	Furrowed	29.2	351.3	93.0
	Gouged	30.5	309.9	126.7
Nordan crested wheatgrass	Control	36.5	1,687.8	428.1
	Furrowed	60.0	1,343.3	472.2
	Gouged	35.7	1,076.4	296.5
Fairway crested wheatgrass	Control	13.3	275.6	41.2
	Furrowed	70.0	2,135.6	410.7
	Gouged	66.7	1,308.9	233.7
Basin wildrye	Control	8.5	459.3	99.2
	Furrowed	21.7	206.7	7.1
	Gouged	5.3	167.6	19.4
Canadian wildrye	Control	32.5	103.4	125.6
	Furrowed	47.5	137.8	74.8
	Gouged	40.0	68.8	60.8
Indian ricegrass	Control	---	---	---
	Furrowed	12.3	68.8	---
	Gouged	8.3	96.3	7.1
Buffalo grass	Control	32.5	1,377.6	21.1
	Furrowed	55.0	---	---
	Gouged	25.0	---	---
Yellow sweet clover	Control	32.2	1,062.1	---
	Furrowed	90.0	1,171.1	---
	Gouged	28.0	51.6	---

TABLE B-4.--Vegetation data from Upton--Continued

Species	Season / Treatment	Canopy cover (percent) Spring	Density (stems/m^2) Spring	Production (grams/m^2) Spring
Greasewood	Control	10.9	---	---
	Furrowed	20.9	---	---
	Gouged	26.7	---	---
Fourwing saltbush	Control	24.3	---	---
	Furrowed	16.1	---	---
	Gouged	16.0	---	---
Squirreltail	Control	---	---	---
	Furrowed	---	---	---
	Gouged	70.0	137.6	75.8

TABLE B-5.--Vegetation data from Colony (fertilized plots)

Species	Treatment	Canopy cover (percent)		Density (stems/m^2)		Production (grams/m^2)	
		Spring	Fall	Spring	Fall	Spring	Fall
Siberian wheatgrass	None	4.3	16.9	103.3	199.8	9.8	16.5
	100#/acre	---	13.0	68.9	114.8	14.2	20.0
	150#/acre	3.0	20.0	---	241.1	---	24.2
Western wheatgrass	None	11.3	50.5	180.7	597.0	12.0	64.8
	100#/acre	13.3	32.5	206.7	378.9	10.9	45.2
	150#/acre	15.0	28.3	172.2	413.3	10.4	31.6
Thickspike wheatgrass	None	12.5	33.9	367.5	564.0	37.9	46.9
	100#/acre	21.2	55.0	416.1	525.1	40.3	73.0
	150#/acre	11.7	30.0	183.7	378.9	7.0	30.9
Streambank wheatgrass	None	13.9	45.5	538.8	662.1	24.2	68.1
	100#/acre	20.0	43.7	356.0	414.4	35.2	46.7
	150#/acre	17.5	45.0	229.6	608.5	21.2	29.7
Pubescent wheatgrass	None	6.7	36.2	206.7	292.8	16.5	66.6
	100#/acre	1.0	40.0	---	344.5	---	112.6
	150#/acre	3.0	26.7	---	129.2	---	29.2
Nordan crested wheatgrass	None	*	48.9	*	566.4	*	88.7
	100#/acre	*	60.0	*	620.0	*	165.6
	150#/acre	*	66.0	*	838.1	*	159.4
Fairway crested wheatgrass	None	*	62.2	*	795.8	*	76.6
	100#/acre	*	80.0	*	1,351.9	*	197.8
	150#/acre	*	45.7	*	803.7	*	104.7
Basin wildrye	None	2.0	16.1	---	201.5	---	19.4
	100#/acre	---	4.3	---	---	---	---
	150#/acre	---	10.0	---	---	---	---
Indian ricegrass	None	---	8.1	---	146.4	---	6.7
	100#/acre	---	17.5	---	86.1	---	8.9
	150#/acre	---	5.0	---	---	---	---
Yellow sweet clover	None	70.0	42.5	---	---	---	---
	100#/acre	1.0	---	---	---	---	---
	150#/acre	---	---	---	---	---	---

*This species was not seeded here in the spring.

TABLE B-6.--Summary of individual species results without seasonal differentiation

Species	Treatment	Canopy cover (percent)	Density (stems/m^2)	Production (grams/m^2)
Siberian wheatgrass	Control	19.2	493.3	176.9
	Furrowed	17.5	334.2	93.8
	Gouged	14.9	359.9	29.3
Western wheatgrass	Control	28.8	480.4	65.3
	Furrowed	26.5	370.0	59.2
	Gouged	24.6	516.4	44.7
Thickspike wheatgrass	Control	30.3	576.4	64.8
	Furrowed	42.5	663.4	77.8
	Gouged	34.7	692.2	69.1
Streambank wheatgrass	Control	31.2	702.0	83.6
	Furrowed	32.7	587.1	61.5
	Gouged	31.0	689.0	67.6
Pubescent wheatgrass	Control	22.6	182.3	47.0
	Furrowed	28.0	240.5	67.3
	Gouged	25.0	368.1	79.3
Nordan crested wheatgrass	Control	33.6	583.7	111.8
	Furrowed	40.6	659.6	159.7
	Gouged	33.6	687.8	161.7
Fairway crested wheatgrass	Control	30.6	622.3	68.5
	Furrowed	48.3	866.9	98.7
	Gouged	50.7	787.4	88.6
Basin wildrye	Control	11.0	240.5	42.7
	Furrowed	10.5	105.5	14.2
	Gouged	13.1	165.0	30.2
Canadian wildrye	Control	32.5	103.4	125.6
	Furrowed	47.5	137.8	74.8
	Gouged	35.0	68.8	60.8
Indian ricegrass	Control	6.7	80.9	4.0
	Furrowed	9.9	56.1	5.2
	Gouged	92.7	101.6	6.7
Buffalo grass	Control	14.8	1,377.6	21.1
	Furrowed	11.0	94.7	---
	Gouged	13.0	---	---
Yellow sweet clover	Control	40.2	814.2	---
	Furrowed	54.0	581.3	---
	Gouged	44.7	475.6	---

TABLE B-6.--Summary of individual species results without seasonal differentiation--Continued

Species	Treatment	Canopy cover (percent)	Density (stems/m^2)	Production (grams/m^2)
Greasewood	Control	9.1	---	---
	Furrowed	16.7	---	---
	Gouged	25.7	---	---
Fourwing saltbush	Control	24.3	---	---
	Furrowed	16.1	---	---
	Gouged	16.0	---	---
Squirreltail	Control	---	---	---
	Furrowed	---	---	---
	Gouged	70.0	137.6	75.8
Rubber rabbitbrush	Control	1.0	---	---
	Furrowed	1.0	---	---
	Gouged	---	---	---

TABLE B-7.--Summary of seeding rate results

Mixture	Rate[1]	Canopy cover (percent)	Density (stems/m^2)	Production (grams/m^2)
GV-1--------	0.50x	69.4	1,072.1	69.9
	0.75x	64.4	960.9	102.8
	1.00x	81.6	1,282.2	122.2
	1.50x	69.0	1,361.4	116.5
	2.00x	75.6	1,225.4	101.2
RP-1--------	0.50x	45.7	773.3	69.4
	0.75x	46.9	693.3	66.5
	1.00x	58.2	971.8	72.3
	1.50x	51.3	768.6	73.9
	2.00x	57.4	740.0	68.4
ACU-1--------	0.50x	35.3	551.3	33.6
	0.75x	36.1	675.2	38.6
	1.00x	34.9	851.5	52.4
	1.50x	35.3	759.5	50.9
	2.00x	45.5	575.1	47.4
ACU-2--------	0.50x	42.6	865.5	56.5
	0.75x	39.4	952.8	65.0
	1.00x	57.0	876.2	59.2
	1.50x	44.3	906.4	63.2
	2.00x	40.7	933.9	84.8

[1]Multiple of the recommended seeding rate.

TABLE B-8.[1]--Summary of seasonal results at Alzada without surface treatments differentiation

Species	Season:	Canopy cover (percent) Spring	Canopy cover (percent) Fall	Density (stems/m^2) Spring	Density (stems/m^2) Fall	Production (grams/m^2) Spring	Production (grams/m^2) Fall
Siberian wheatgrass		3.7	8.9	200.5	88.5	22	32.7
Western wheatgrass		16.7	15.6	370.3	330.7	63.8	78.7
Thickspike wheatgrass		---	20.2	---	449.1	---	57.1
Streambank wheatgrass		14.1	28.2	319.4	732.5	49.5	76.1
Pubescent wheatgrass		7.4	17.3	84.0	261.8	20.7	56.0
Nordan crested wheatgrass		---	32.1	---	479.3	---	90.8
Fairway crested wheatgrass		---	38.7	---	514.9	---	89.0
Basin wildrye		8.0	4.8	1.7	36.2	---	2.8
Canadian wildrye		20.0	---	---	---	---	---
Indian ricegrass		---	4.5	---	45.9	---	2.5
Yellow sweet clover		20.3	28.8	34.4	185.1	---	---
Greasewood		2.0	15.0	---	---	---	---

[1]These results are not a compendium of results from all sites because of the climatic variation from site to site. As such each site has been summarized individually, above and in the following tables (tables B-8, B-9, B-10, B-11, and B-12).

TABLE B-9.--Summary of seasonal results at Colony without surface treatments dfferentiation

Species	Canopy cover (percent) Spring	Canopy cover (percent) Fall	Density (stems/m^2) Spring	Density (stems/m^2) Fall	Production (grams/m^2) Spring	Production (grams/m^2) Fall
Siberian wheatgrass	3.3	17.2	17.2	264.4	---	49.2
Western wheatgrass	25.5	42.9	187.5	554.8	19.0	87.3
Thickspike wheatgrass	---	45.9	---	910.8	---	102.4
Streambank wheatgrass	18.2	48.1	371.2	761.9	34.0	59.7
Pubescent wheatgrass	20.3	41.4	193.7	323.8	34.3	76.1
Nordan crested wheatgrass	---	56.2	---	679.2	---	124.1
Fairway crested wheatgrass	---	64.1	---	1,326.0	---	144.3
Basin wildrye	4.0	13.9	15.0	119.0	8.0	38.0
Canadian wildrye	14.4	---	132.0	---	34.4	---
Indian ricegrass	---	10.5	---	71.0	---	5.1
Buffalo grass	---	2.4	---	94.7	---	---
Yellow sweet clover	3.0	25.0	---	---	---	---

TABLE B-10.--Summary of seasonal results at Glasgow without surface treatments dfferentiation

Species \ Season	Canopy cover (percent)		Density (stems/m^2)		Production (grams/m^2)	
	Spring	Fall	Spring	Fall	Spring	Fall
Siberian wheatgrass	7.5	8.2	---	---	---	55.6
Western wheatgrass	18.1	19.3	291.9	388.9	26.1	32.0
Thickspike wheatgrass	26.1	43.8	364.4	750.3	21.3	63.5
Streambank wheatgrass	14.1	34.4	350.1	632.4	20.3	39.7
Pubescent wheatgrass	14.4	27.2	96.4	206.7	11.0	34.1
Nordan crested wheatgrass	12.5	32.1	180.5	327.2	18.0	43.6
Fairway crested wheatgrass	18.4	38.5	203.3	452.9	13.9	36.2
Basin wildrye	1.3	24.1	---	223.9	---	24.7
Indian ricegrass	1.0	11.6	---	82.7	---	6.3
Buffalo grass	---	1.1	---	---	---	---
Yellow sweet clover	49.5	79.3	394.2	730.3	---	---
Rubber rabbitbrush	1.0	1.0	---	---	---	---

TABLE B-11.--Summary of seasonal results at Upton without surface treatments dfferentiation

Species	Canopy cover (percent)	Density (stems/m^2)	Production (grams/m^2)
Siberian wheatgrass	39.0	634.1	217.1
Western wheatgrass	41.5	615.6	74.4
Thickspike wheatgrass	47.5	661.1	120.1
Streambank wheatgrass	48.2	1,014.4	128.8
Pubescent wheatgrass	30.9	331.7	112.6
Nordan crested wheatgrass	44.8	1,305.4	351.8
Fairway crested wheatgrass	50.9	1,102.3	243.5
Basin wildrye	11.5	117.1	43.7
Canadian wildrye	345	327.7	96.5
Indian ricegrass	10.3	87.2	6.9
Buffalo grass	36.3	1,377.6	21.1
Yellow sweet clover	38.4	881.8	---
Greasewood	19.4	---	---
Fourwing saltbush	19.1	---	---
Squirreltail	70.0	757.1	---

TABLE B-12.--Summary of seasonal results at Colony (fertilized plots) without surface treatments dfferentiation

Species \ Season	Canopy cover (percent)		Density (stems/m^2)		Production (grams/m^2)	
	Spring	Fall	Spring	Fall	Spring	Fall
Siberian wheatgrass	4.0	16.0	86.1	182.6	12.0	19.4
Western wheatgrass	12.5	41.8	185.1	532.5	11.5	54.4
Thickspike wheatgrass	14.5	38.4	340.0	516.6	32.4	49.6
Streambank wheatgrass	16.0	45.0	425.3	590.1	26.2	55.6
Pubescent wheatgrass	3.6	35.3	206.7	274.2	16.5	68.3
Nordan crested wheatgrass	---	54.9	---	630.7	---	123.3
Fairway crested wheatgrass	---	65.6	---	936.3	---	106.5
Basin wildrye	2.0	12.4	---	201.5	---	19.4
Indian ricegrass	---	9.2	---	126.3	---	7.4
Yellow sweet clover	35.5	42.5	---	---	---	---